Comparison of support surface performance characteristics for flap and graft applications

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Summary

Despite widespread adoption of prevention strategies, pressure injuries remain a significant problem across all healthcare settings. The underlying cause and formation of pressure injuries is multifaceted with a number of contributing factors, notably impaired mobility.[1] New insights on pressure injury development suggest three major contributors to cell damage namely deformation, inflammation and ischemia[2] and suggests that cell deformation damage can happen in a matter of minutes with ischemic tissue damage manifesting within several hours. This new perspective demonstrates the importance of minimizing exposure to sustained tissue deformation (pressure, shear) and highlights the importance of early detection in pressure injury prevention.[2] This is particularly the case in critical tissue conditions involving sensitive anatomical locations e.g. the sacrum or surgical wound sites such as a flap or skin graft.

The 2019 International Pressure Injury Guideline views support surface technologies as an important component in pressure injury prevention and treatment since they can help prevent the effects of damaging tissue deformation and provide an environment that enhances perfusion of at risk or injured tissues.[3] The Guideline recommends choosing a support surface that takes into account the individuals specific needs, including level of immobility and inactivity, the need to influence microclimate control and shear reduction, the size and weight of the individual and the number, severity and location of existing pressure injuries.[3]

Over recent years, an increasing body of evidence suggests that microclimate between the skin and the support surface plays a role in the development of pressure injuries. The term microclimate refers to the temperature, humidity and airflow next to the skin.[1] Managing microclimate helps improve tissue tolerance to pressure, friction and shear.[4]

While the majority of pressure injuries heal without the need for surgical intervention, a significant number of deep tissue and full thickness injuries require surgical repair using a muscle or fasciocutaneous flap or skin graft. Such procedures aim to restore skin integrity and its barrier function to prevent infection, maintain normal functioning and to minimize disfigurement.[5] Complications post flap/graft procedure are common with rates estimated to be around 18.6%.[6] In a systematic review involving 1,184 patients, the most common complications were wound dehiscence (9.7–11%), necrosis (5.1–9%) and infection (4.3–7.5%).[6]

Post-operative management of flaps and grafts

Individuals who have undergone flap or graft repair are at a higher risk for developing additional pressure injuries due to reduced mobility and postoperative limitations for positioning.[7] Vigilant postoperative care including a specialty support surface and a positioning regime is essential for positive patient outcomes. According to the International Pressure Injury Guideline[1] support surface features to consider for the postoperative care of flaps and grafts include pressure redistribution properties, and the management of friction, shear forces and microclimate.

Since the 1980's many surgeons have used air-fluidized therapy (AFT) support surfaces in the immediate postoperative period for patients who have undergone flap surgery. Over time, use of alternating pressure and low air loss surfaces have become firmly established as viable alternatives in the postoperative management of this patient population[6] and are listed as support surface considerations following pressure injury surgery in the 2019 International Guideline.[1]

The variation in support surface utilization for postoperative flap patients is clearly demonstrated in the results of an online survey[8] completed in 2019 by a random sample of sixty-six Wound, Ostomy and Continence Nurses (WOCNs) currently treating postoperative flap patients within the United States (Figure 1). The survey also revealed practice diversity regarding positioning protocols for postoperative flap patients. Most surveyed WOCNs reported postoperative positioning on the flap/graft surgical site within 24 hours. Repositioning practices are influenced by the surgeon's orders for bedrest or wound offloading depending on the location of the surgical and donor site. Other considerations in repositioning include the use of wedges, pillows, boots, the degree of head of bed elevation, and use of prone positioning. As the incision site heals, most facilities have a protocol in place that allows for dangling and progressive sitting, with pressure redistribution interventions to eliminate sustained pressure. With an increase in sitting tolerance and incision healing, the patient is often transitioned from a powered to a non-powered support surface in readiness for discharge home.

Type of support surface used for postop flap and graft patients (n=66)

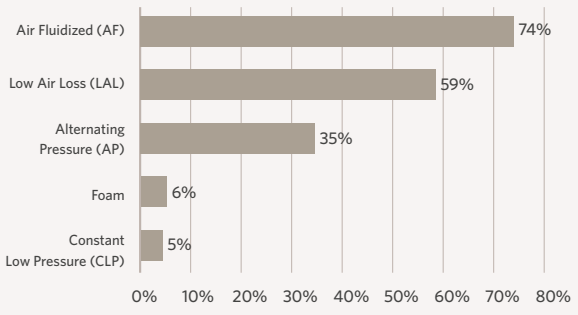
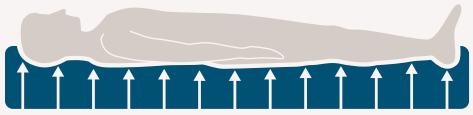


Figure 1: Results from a 2019 online survey of US based WOCNs

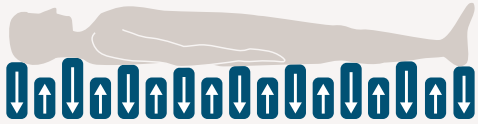
Comparison between two of Arjo's support surfaces: the Citadel® C200 + Skin IQ® and KinAir MedSurg Pulse

The KinAir MedSurg Pulse is a legacy Arjo integrated support surface providing Low Air Loss and Pulsating Air Suspension Therapy and is indicated for patients with burns or postoperative flap or graft surgery as well as for the prevention and treatment of pressure injuries. The Citadel Patient Therapy System C200 model is an integrated pressure redistribution surface providing reactive and active surface technology and pulsation therapy (Figure 2).

Citadel Patient Therapy System C200



Reactive mode



Active (Alternating Pressure) mode

Figure 2: Citadel C200 Patient Care System and example modes

The Citadel C200 is indicated for the prevention and treatment of pressure injuries, although clinicians have reported use of the C200 with postoperative flap patients. Within clinical practice, the Skin IQ Microclimate Manager (MCM), an adjunctive therapeutic mattress coverlet for microclimate control, is used in conjunction with the C200 support surface. The Skin IQ MCM (Figure 3) is a fluid resistant, vapor permeable, single patient or multiple patient use coverlet that applies negative airflow technology to draw moisture vapor and heat away from the skin surface interface to help prevent excess moisture, humidity and heat buildup (Figure 4).

Figure 3: Citadel C200 + Skin IQ MCM

Citadel C200 support surface operating mode and therapy parameters

The Citadel C200 system has multiple therapy modes and feature options to adjust or alter the air pressure within this specialty support surface. Adjustments to the Citadel C200 support surface allows for air pressure configuration according to the needs of a patient.[9] The operating adjustments described in Figure 5 (a–d) will have an impact on the air pressure within the support surface and the pressure redistribution achieved. These properties can be measured through the resulting parameters of interface pressure, immersion and envelopment.

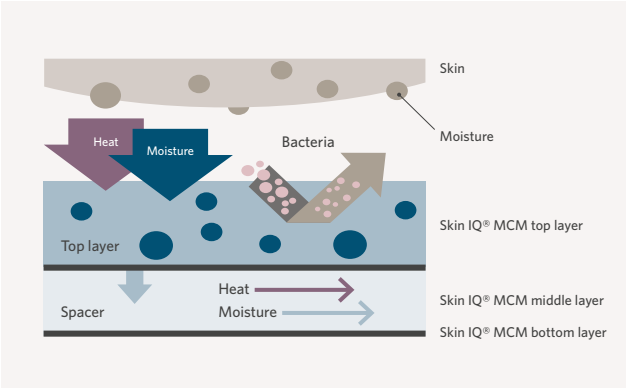
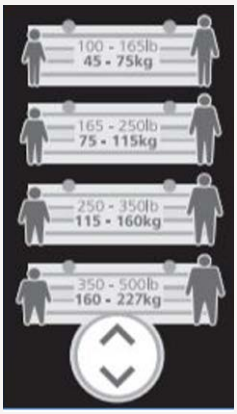
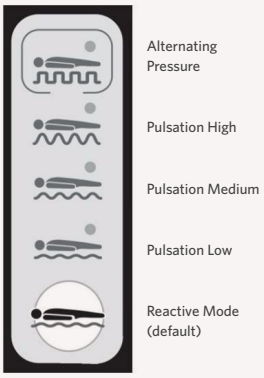


Figure 4: Skin IQ MCM Schematic

a) Altering the patient weight/height pre-set range.



b) Changing the operating mode from the default Reactive mode to Pulsation or Alternating Pressure mode will result in a different level of immersion.[10]



c) For example, selecting Alternating Pressure mode (Active Therapy) provides periodic offloading of tissue and increases immersion.

d) Using the manual adjustment to customize pressure levels within specific regions of the mattress can further reduce the pressures at the anatomical area of concern.

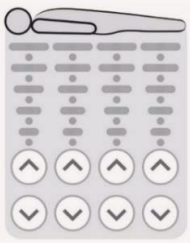


Figure 5: Options for adjusting Citadel C200 Operating Mode and Therapy Parameters

Laboratory performance testing results

To understand the performance of the Citadel C200 + Skin IQ MCM and how it compares to the performance of the legacy KinAir MedSurg Pulse, assessment and testing was performed to the US National Standard (SS-1:2019)[11] using a combination of external independent test laboratories and internal measurements. Since the microclimate performance of the C200 + Skin IQ demonstrated superior operation, the results were compared with commonly used high performance support surfaces in the US market.

1. Support surface horizontal stiffness (shear) test – SS-1:2019 Section 5[11]

The purpose of this test is to measure the force necessary to slide an anatomically representative part of a mannequin across the support surface. This allows a comparative measurement of the sliding forces (shear force) provided by each surface and is an analogue to the expected forces encountered when patient movement occurs on the surface.

Results: Comparison tests were performed between the C200 + Skin IQ MCM and an existing legacy product, KinAir MedSurg Pulse which is indicated and widely used for Flap and Graft applications. Figure 6 shows the C200 + Skin IQ MCM has a lower horizontal stiffness and so offers less resistance to patient motion on the surface. This reduces the effects of shear, which is critical for patients with sensitive tissue areas.

The initial point (at t=0) on the graph (Figure 6) shows the static force that prevents the movement of the mannequin (patient) which has to be overcome in order for movement to occur. Once movement starts, the force is then known as dynamic force. The dynamic force shown in the graph acts on the mannequin during movement and is comparable to forces during repositioning and in-bed movement. The lower initial static and dynamic forces measured with the C200 + Skin IQ MCM can be expected to reduce the shear effect and tissue strain on the patient when repositioned. The C200 + Skin IQ MCM shows a considerable improvement to the horizontal stiffness performance compared to the legacy product.

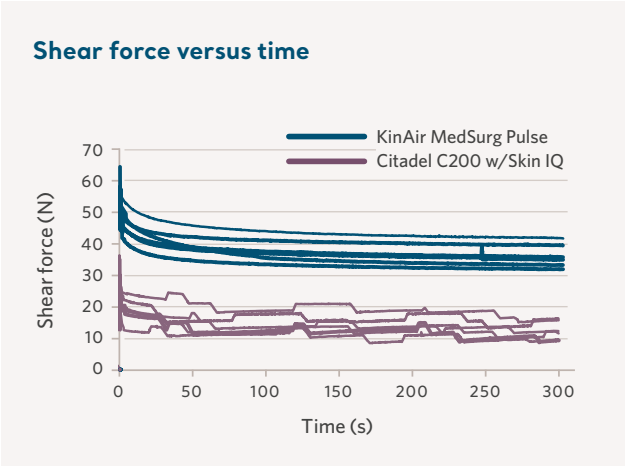


Figure 6: Comparison of horizontal stiffness results for the KinAir MedSurg Pulse compared to the C200 + Skin IQ.[13]

2. Envelopment and immersion – hemispherical indenter test – SS-1:2019 Section 6[11]

The depth of immersion of a support surface is an important characteristic. Increased immersion can lead to an increase in envelopment. The pressure redistribution provided by a reactive surface can improve if the patient's body is in contact with a larger surface area.

Results: The average immersion level provided by the Citadel C200 + Skin IQ for each operating mode was compared to the KinAir MedSurg Pulse in its High Pulsation Mode (Figure 7). Despite these two products significantly differing in heights, construction and operation, it is possible to compare them in terms of their immersion and envelopment.

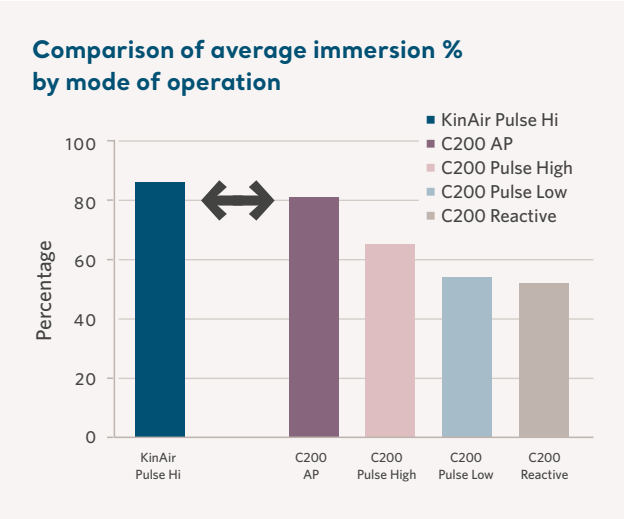


Figure 7. Immersion test data.[13]

The Citadel C200 in Alternating Pressure (AP) mode provides a broadly equivalent percentage depth of immersion to the KinAir MedSurg® Pulse as represented in Figure 7.

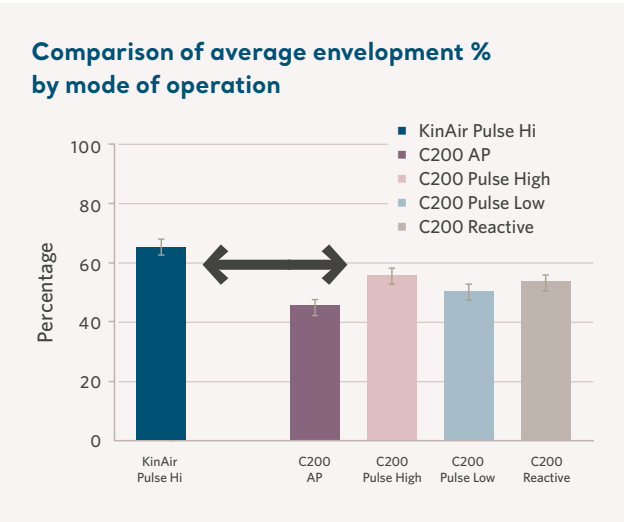


Figure 8. Average Envelopment data comparing KinAir MedSurg Pulse (High Pulse mode) to Citadel C200[13]

The range of envelopment % of the KinAir MedSurg Pulse is higher than the Citadel C200, however the performance can be most closely matched through the use of Citadel C200 + Skin IQ in Pulsation High Mode (Figure 8).

3. Standard protocol for measuring heat and moisture dissipation characteristics of full body support surfaces – sweating guarded hot plate method (SGHP) SS-1:2019 Section 4[11]

Microclimate assessment used the RESNA SS-1:2019 Section 4 SGHP method. The purpose of this test is to identify the ability of the support surface to remove heat and moisture from the patient interface. There is a growing appreciation of the role of microclimate management in helping to improve tissue tolerance to aid in pressure injury prevention and management, particularly in the presence of excessive moisture and elevated temperature at the skin/surface interface.[12] Any surface that is in contact with the skin has the potential to affect the microclimate. The overall effect is dependent on the nature of the support surface and the cover.[12]

A heated, moist indenter measures the resistance to flow of heat and humidity through a support surface simulating the skin in contact with the support surface.[11] The evaporative capacity reported by the test details the ability of the support surface to dissipate moisture at the patient interface.

Results: The C200 + Skin IQ MCM was compared with examples of other commonly used support surfaces readily available in the US market and this is shown graphically in Figure 9.

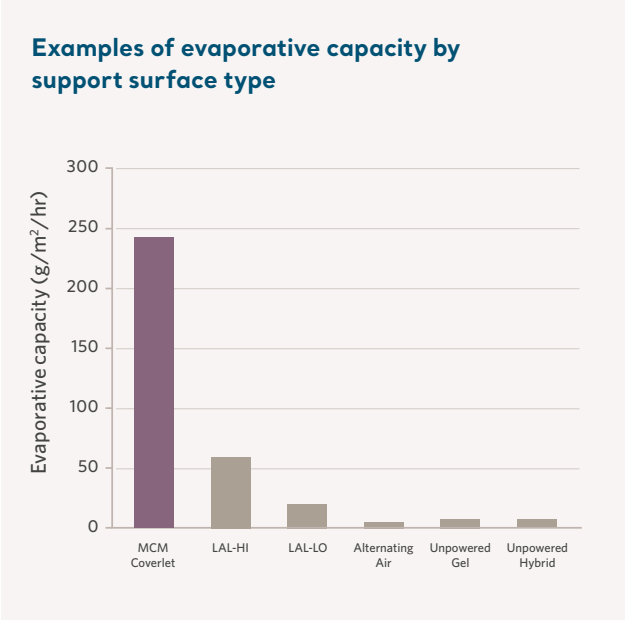


Figure 9: Comparative test results using the SGHP method[13]

4. Standard protocol for measuring heat and water vapor dissipation characteristics for full body support surfaces – body analog method – SS-1:2019 Section 3[11]

Microclimate assessment used the RESNA SS:1 2019 Section 3 – The Body Analog Test Method. The test purpose is to measure heat and moisture dissipation properties of the support surface by creating a comparable environment to the human body lying on a mattress[11]. The test also includes a simulated repositioning event (shown at time = 180 minutes) demonstrating the ability of the surface to return to its original state prior to surface loading. A Thermodynamic Rigid Cushion Loading Indenter is used to generate, control and measure the environmental conditions of temperature and relative humidity (% RH) at the patient interface.

Results: Within the test conditions, the % RH at the interface of the indenter to the surface was kept at a steady state demonstrating that the C200 + Skin IQ was able to quickly stabilize and remove a significant portion of the humidity introduced from the test environment (Figure 10). The flat nature of the curve shows that the C200 + Skin IQ is able to control and limit the increase in moisture at the simulated skin interface compared to a reference surface. The testing occurred over a three-hour timeframe that simulates a typical period of patient immobility. This demonstrates the beneficial microclimate effect that could be present in a real life clinical situation. Humidity can have an adverse effect on tissue viability and often results in moisture being condensed and trapped under the patient's body.

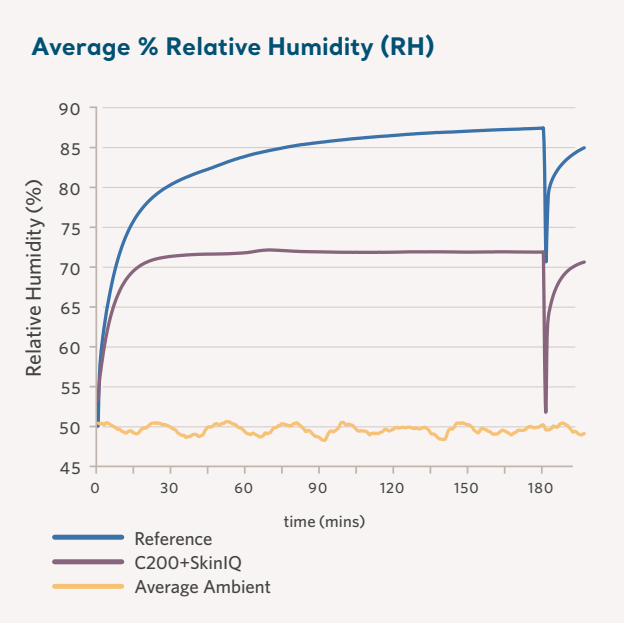


Figure 10: Test results using the Body Analog method[13]

Conclusion

Vigilance is required in the postoperative care of patients requiring flap or graft surgery for difficult to heal deep tissue or full thickness pressure injuries. Care of the wound and prevention of further pressure injury involves many factors including rigorous positioning protocols often determined by the surgeon and use of a support surface with low air loss/microclimate management, alternating pressure or air fluidized technologies.

Many product features within the design, construction and operation differ between the KinAir MedSurg Pulse and the Citadel C200 + Skin IQ. However, in terms of key measurable parameters, the user can readily configure the Citadel C200 system at the bedside to provide a broadly comparable level of surface performance to address the clinical needs of the postoperative patient. Based on these measurable parameters, the utilization of the Citadel C200 could provide an acceptable alternative to air fluidized therapy (AFT) or low air loss (LAL) support surfaces for the postoperative patient.

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